



Seroprevalence of Tropical Theileriosis (*Theileria annulata*) and Associated Ticks (Acari: Ixodidae) in Cattle in Morocco

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ABSTRACT

A study was conducted in 2021 and 2022 across two irrigated provinces in Morocco, Al Haouz and Fkih Ben Salah, to assess the seroprevalence of tropical theileriosis and identify associated tick species. The study also analysed the influence of breeding type and cattle origin on *Theileria annulata* infection. Serological diagnosis was performed using the indirect fluorescent antibody test (IFAT) and statistical analysis was carried out using the Chi-square test (χ^2 Kramer). 480 blood samples from cattle were analysed, and 2,500 ticks were collected. Among the farms visited, 91.66% were infected with *T. annulata*, and 83.33% had tick infestations. The seroprevalence of *T. annulata* in Fkih Ben Salah and Al Haouz was 55.00 and 66.66%, respectively. Ten tick species, belonging to the genera *Hyalomma* and *Rhipicephalus*, were identified, with *Hyalomma scupense* being the most prevalent and abundant species in both provinces (P=41.25% in Fkih Ben Salah and P=32.5% in Al Haouz). The type of cattle breeding and the origin of the animals were found to influence *T. annulata* infection rates significantly. This study highlights that, despite fifty years of importing new cattle breeds to Morocco, the epidemiological situation of tropical theileriosis remains unstable in many cattle farming regions. Al Haouz and Fkih Ben Salah have become important foci of the disease, providing favourable conditions for tick survival. The study also emphasizes the notable presence of *Hyalomma marginatum*, a species known for transmitting pathogens to humans, such as the virus responsible for Crimean-Congo hemorrhagic fever.

Key words: Tropical theileriosis, *Theileria annulata*, Seroprevalence, Ticks, *Hyalomma scupense*, cattle, Morocco.

INTRODUCTION

Tropical theileriosis is an infectious but non-contagious tick-borne protozoan disease of cattle (zebu and buffalo) resulting from the presence and multiplication in mononuclear leukocytes and erythrocytes of an obligate intracellular protozoan belonging to genera *Theileria*; *T. annulata* (Zweygarth et al. 2020). Infection of mononuclear leukocytes results in uncontrolled and cancer-like multiplication of these cells. Schizont forms of this protozoa then transform into other forms called piroplasms that infect erythrocytes, and can then be ingested by ticks that feed on cattle blood (Liu et al. 2022). In North Africa, this protozoan is transmitted by the tick *Hyalomma scupense* (Agina et al. 2020, Aouali et al. 2024, Kernif et al. 2024). This species is monotropic and has become endophilic in various parts of the world (Benchikh Elfegoun et al. 2019, Bonnet et al. 2023). *H. scupense* is a

one or two-host tick, domestic cattle are the most common hosts for adults and immature stages, but almost all ungulates may be infested.

Tropical theileriosis exists throughout the Mediterranean region, the Middle East, and South Asia. The disease poses a serious barrier to exotic cattle breeding imported from Europe and Asia (Gharbi et al. 2020; Perveen et al. 2021). In North Africa (Maghreb), tropical theileriosis is perceived to be the most important factor restricting the introduction of improved breeds of cattle (Darghouth et al. 1996; Elhachimi et al. 2021). In Morocco, tropical theileriosis is one of the most severe bovine diseases, the most important economically and the most prevalent protozoan disease in cattle (Ouhelli and Flach 1990; El Haj et al. 2002; Rahali et al. 2014).

In Morocco, the disease is seasonal; most cases occur from April to September with a peak in July-August, followed closely by a peak in the number of adult vector *H. scupense*

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ticks (Flach and Ouhelli 1992; Bedouhene et al. 2022). Since the introduction of European exotic breeds to Morocco fifty years ago and the development of intensive breeding, this disease has become, and continues to be, a serious issue, despite significant efforts by Moroccan authorities to control it through acaricide use. Tropical theileriosis has a significant economic impact in developing countries (Singh 1991; Chaudhry et al. 2022; Boulkaboul 2023). In Morocco, the losses caused by theileriosis were estimated to range from 300 to 650 Moroccan Dirhams (MAD) (1\$=10MAD) per animal, excluding the additional costs associated with acaricide use. Therefore, controlling the disease through drug treatment is not viable due to the treatment's ineffectiveness and farmers' noncompliance. Generally, animals that have suffered from acute theileriosis have a reduced economic value (Ganaie et al. 2019; Tripathi and Jaiswal 2024; Strydom et al. 2023).

The objectives of this study were: 1) to assess the seroprevalence of tropical theileriosis in two provinces with high dairy cattle potential that were previously free of the disease before the introduction of exotic cattle, 2) to determine the prevalence of the vector tick, and 3) to evaluate the impact of farm type and cattle origin on the spread of the disease. A better understanding of the epidemiology of tropical theileriosis in Morocco will allow for the development of an effective strategy to control the disease.

MATERIALS AND METHODS

Study areas

Province of Fkih Ben Salah (32°30'00" N; 6°42'00" W)

Situated at an altitude of 437 meters, (Fig. 1). The climate is semi-arid and Mediterranean continental, with a humid season from November to March and a dry season from April to October. The average annual temperature is 18°C, with summer highs ranging from 38 to 40°C in August and winter lows between 3 and 4°C in January.

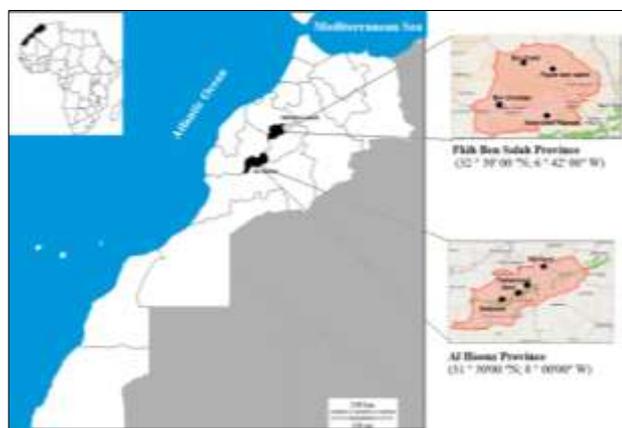


Fig. 1: Geographic location of the study areas.

Province of Al Haouz (31°30'00" N; 8°00'00" W)

Situated at an altitude ranging from 1,000 to 1,500 meters (Fig. 1). The climate is semi-arid with Mediterranean continental characteristics, and rainfall is irregular, ranging from 250 to 490mm depending on the altitude. Temperatures are high, with significant daily and annual thermal variations (average maximum temperatures of

18°C in January and 38°C in July, and minimum temperatures of 5°C in January and 19°C in July). Relative humidity is low, averaging around 40% in the summer.

Animals

Six farms from each municipality (3 traditional types and 3 modern types) were included in this study for a total of 48 farms (24 modern and 24 traditional) in the two provinces. Blood sampling and tick collection were performed only on cattle. A total of 480 cattle were examined, consisting of 280 crossbreeds and 200 local breeds.

Blood sampling and serological analysis, blood samples were collected in 10 bovines from each of the 48 farms, a total of 480 blood samples. The blood of each animal was taken from the jugular vein and placed in a dry tube. The sera were brought to the Laboratory of Parasitology of the Agronomic and Veterinary Institute, Hassan II (IAV) in Rabat, Morocco, and separated by centrifugation and stored at -20°C. All samples collected from animals were conducted following relevant ethical guidelines and regulations. Serological analysis was performed in the IAV laboratory using the indirect fluorescence antibody test (IFAT, VMRD Test Kit) for the detection of antibodies of *T. annulata*. Dried films of *T. annulata* schizonts have been prepared according to the technique described by Burrige (1971) and Mackiewicz et al. (2020). Positive and negative *T. annulata* schizont antigen control sera were prepared at the IAV laboratory. The sera were screened at a dilution of 1/160. Samples giving a positive reaction to schizont IFAT were again tested with dilutions of 1/640. Animals showing positive serology were considered to be infected by *T. annulata*.

Identification of ticks

Ticks and blood samples were collected simultaneously from the same animals. Adult and nymphal ticks were collected from the nipples, perineum, ears, and neck by simple extraction after immobilization of the animal. Ticks were stored in vials containing ethanol at -70°C and then identified at IAV based on the morphoanatomical characteristics described by Walker et al. (2003). Parasitic indices (prevalence, abundance and mean intensity of infestation) were estimated as described by Margolis et al. (1982).

Statistical Analysis

Statistical analysis was performed using the Chi-square test (χ^2) of Cramer. χ^2 takes values between 0 and infinity. If $\chi^2 = 0$ it means that there is no correlation between the two variables. Cramer's coefficient (K) is a reduced centred form of χ^2 ($K = \sqrt{\chi^2 / n + \chi^2}$). Therefore, it varies between 0 and 1. The closer the value of K is to 1, the more there is a correlation between the two variables.

RESULTS

Seroprevalence

The results of the serological survey are shown in Table 1. 301 Of 480 sera analysed, were seropositive for *T. annulata*. The province of Al Haouz had the highest seroprevalence with 160 positives, ranging from 51.66 to 85% among municipalities. In Fkih Ben Saleh, 141 were seropositive ranging from 46.66 to 86.66% between municipalities.

Tick species and parasitic indices

The results of the tick collection are shown in Table 2 and 3. 2,500 ticks (2,445 adults and 55 nymphs) were collected. Ten tick species belonging to two genera were identified: *Hyalomma scupense* (Schulze, 1919), *Hyalomma marginatum* (Koch 1844), *Hyalomma lusitanicum* (Senevet 1922), *Hyalomma excavatum* (Koch 1844), *Hyalomma dromedarii* (Koch 1844), *Hyalomma impeltatum* (Schulze and Schlottke 1930), *Rhipicephalus bursa* (Canestrini and Fanzago, 1878), *Rhipicephalus turanicus* (Pomerantsev 1936), *Rhipicephalus sanguineus* (Latreille 1806) and *Rhipicephalus (Boophilus) annulatus* (formerly *Boophilus annulatus* , (Say 1821). All

collected nymphs were *Rhipicephalus*. The genus *Hyalomma* was the most abundant overall at 71.56% (1,789/2,500); 77.96% (1132/1452) in Fqih Ben Salah and 66.11% (651/1048) in Al Haouz. *H. scupense* was the most abundant species at 35.52% (888/2500), 34.82% (365/1048) in Al Haouz and 36.01% (523/1452) in Fkih Ben Salah.

The results showed that 90.35% of the sera evaluated from crossbreeds were seropositive for *T. annulata* while only 24% of the sera from local breed animals were seropositive. Furthermore, 91.66% of the cattle raised in traditional farms were seropositive compared to 33.75% of the cattle raised in modern farms (Table 4).

Table 1: Seroprevalence of *T. annulata* in cattle in Al Haouz and Fkih Ben Salah

Province	Municipality	Number of analyzed sera	Number of positive sera	Seroprevalence by Municipality (%)	Seroprevalence by Province (%)
AL Haouz	Ait Ourir	60	51	85	66.66
	Tahannaout	60	45	75	
	Asni	60	31	51.66	
	Amizmiz	60	33	55	
	Sebt W Namma	60	32	53.33	
Fkih Ben Salah	Fqih BenSaleh	60	52	86.66	58.75
	Bni Oukil	60	28	46.66	
	Bni Chegdale	60	29	48.33	
Total		480	301		Overall Seroprevalence 62.70

Table 2: Number of specimens of all tick species collected from cattle in the two surveyed provinces

Number of ticks collected by Province	Municipality	Number of specimens collected										Total by municipality
		<i>H. scu</i>	<i>H.Mar</i>	<i>H.Lus</i>	<i>H.exc</i>	<i>H.imp</i>	<i>H.dro</i>	<i>R.san</i>	<i>R.tur</i>	<i>R.bur</i>	<i>R. B. ann</i>	
AL Haouz (1048)	Ait ourir	125	53	35	21	-	-	20	27	56	34	371
	Tahanaout	107	32	20	13	8	15	30	-	12	-	237
	Asni	85	30	-	15	-	-	-	-	37	23	190
	Amizmiz	48	11	-	33	-	-	14	-	38	106	250
	S Namma	145	67	-	74	-	-	23	54	-	42	405
F. B. Salah (1452)	F. B. Salah	131	53	31	52	-	-	31	40	18	-	356
	Bni Oukil	135	49	52	83	23	31	54	-	20	-	447
	B Chegdale	112	58	-	42	-	-	16	-	16	-	244

Table 3: Parasitic indices of all tick species collected in Al Haouz and Fkih Ben Salah

Number of cattle examined Province	Species identified	Number of specimens Collected	Number of cattle infested by each species	Prevalence (P %)	Relative abundance (A)	Mean intensity of infestation (I)
AL Haouz (240)	<i>H. scu.</i>	365	78	32.5	0.35	4.67
	<i>H. mar</i>	126	34	14.16	0.12	3.70
	<i>H. lus.</i>	55	6	2.5	0.05	9.16
	<i>H. exc</i>	82	18	7.5	0.07	4.55
	<i>H. imp</i>	8	2	0.83	0.00	4
	<i>H. dro</i>	15	2	0.83	0.01	7.5
	<i>R. san</i>	64	6	2.5	0.06	10.66
	<i>R. tur</i>	27	4	1.66	0.02	6.75
	<i>R. bur</i>	143	12	5	0.13	11.91
	<i>R. B. ann</i>	163	26	10.83	0.15	6.26
	<i>H. scu</i>	523	99	41.25	0.36	5.28
	<i>H. mar</i>	227	41	17.08	0.15	5.53
	<i>H. lus</i>	83	16	6.66	0.05	5.18
	<i>H. exc</i>	251	34	14.16	0.17	7.38
Fkih Ben Salah (240)	<i>H. imp</i>	23	5	2.08	0.01	4.6
	<i>H. dro</i>	31	7	2.91	0.02	4.42
	<i>R. san</i>	124	18	7.5	0.08	6.88
	<i>R. tur</i>	94	16	6.66	0.06	5.87
	<i>R. bur</i>	54	14	5.83	0.03	3.85
	<i>R. B. ann</i>	42	8	3.33	0.02	5.25

Table 4: Influence of animal origin and type of breeding on cattle infection by *T. annulata*

Origin	Number of sera tested/Category	Number and % of positive sera	Number and % of negative sera	X ²	K
Origin	Local (200)	48 (24)	152 (76)	219.68	0.68
	Crossbreed (280)	253 (90.35)	27 (9.64)		
Type of farm	Traditional (24)	220 (91.66)	20 (8.33)	172.13	0.60
	Modern (24)	81(33.75)	159 (66.25)		

DISCUSSION

Most studies on tropical theileriosis in Morocco have been conducted in Doukkala, the main endemic area of this disease (Ouhelli and Flach 1990; Flach and Ouhelli 1992; Flach et al. 1993; Kachani et al. 1992; Elhachimi et al. 2021). Few studies have examined the provinces of Al Haouz and Fkih Ben Salah (El Haj et al. 2002). However, according to local veterinarians, clinical cases continue to increase in these two provinces. Results of this study indicate that tropical theileriosis is both highly prevalent and widely spread across the two provinces. Among the farms visited, 91.66% (44/48) had seropositive animals, and the overall seroprevalence of *T. annulata* in these provinces was 62.70%. Our results indicate a significant increase in the seroprevalence of *T. annulata* in cattle in the Fkih Ben Saleh region (Tadla) compared to the serological study by El Haj et al. (2002), which reported a seroprevalence of 47%. In contrast, the present study found a seroprevalence of 58.75%, a result similar to those reported by El Damaty et al. (2022). We make this statement with caution, as the two studies employed different assessment methods and the sample sizes remain relatively small. However, despite these limitations, similar seroprevalence results were found in the Al Haouz region (66.66%) in our study compared to 66% in the study by El Haj et al. (2002). If the increase in Fkih Ben Saleh is significant, it could be attributed to the region's proximity to the highly endemic Doukkala area. Additionally, the movement of animals between regions, particularly through weekly markets (Souks), likely increases exposure to the disease. Consequently, regions previously free of tropical theileriosis, such as the Tadla region, may now harbor infected animals. The epidemiological situation is further complicated by the variability in seroprevalence within the same province. In Al Haouz, it ranges from 51.66 to 85%, while in Fkih Ben Saleh, it ranges from 46.66 to 86.66%, both provinces are heavily infested with ticks. The large number of specimens (2,500) and the diverse range of species identified (10) indicate that these provinces offer suitable conditions for tick survival and development. In their study on the prevalence of cattle ticks in four regions of Morocco, Ouhelli and Pandey (1982) found that 100% of the farms visited (24) were infested with ticks. Apart from *H. dromedarii* and *H. impeltatum*, which were reported in this study, their findings included the same species observed here. *Hyalomma* species were the most abundant in terms of numbers. Similar findings have been reported in other studies conducted in different regions of Morocco (Kumar et al. 2020; Elati et al. 2021). *H. scupense* remains the most abundant species, accounting for 35.5% of all ticks collected, a trend observed since the studies by Ouhelli (1988). Bouattour et al. (1996) reported similar results in Tunisia. According to our findings, *H. scupense* was the most prevalent and abundant species in the two surveyed provinces: Al Haouz (P=32.5% and A=0.34) and Fkih Ben Salah (P=41.25% and A=0.35). This species is the primary vector of *T. annulata* in cattle in North Africa, which likely contributes to the high seroprevalence of *T. annulata* in the provinces.

Two other species known to play a role in the transmission of *T. annulata* to cattle in neighbouring countries were also identified. *H. lusitanicum*, the main

vector of *T. annulata* in Spain (García Fernández et al. 2006) and *H. dromedarii*, a vector in Mauritania (Jacquiet et al. 1990), were found in the two surveyed provinces, both with low prevalence (P<10) and low abundance (A<0.1). These species are considered rare. However, the presence of *H. dromedarii* and *H. impeltatum*, which primarily infest dromedaries in the arid Sahara climate, in the surveyed provinces is noteworthy. We consider this presence to be accidental, given the very low parasitic indices. The occasional presence of dromedaries for tourism purposes in these regions may partially explain this observation (Rahali et al. 2016). Somewhat unexpectedly, we also observed a relatively large number of *Rhipicephalus (Boophilus) annulatus* (8.2% of all species collected). It was the third most abundant species in Al Haouz (A=0.15) with a significant prevalence (P>10, <50), thus being considered a satellite species in this province. This tick species is the primary vector of bovine babesiosis caused by *Babesia bovis* and *Babesia bigemina*, as well as bovine anaplasmosis caused by *Anaplasma marginale* in Morocco (Ait Hamou et al. 2012). According to Ouhelli and Pandey (1982), this tick was previously confined to subhumid and humid areas. We propose that its presence in these two semi-arid provinces is expanding, likely due to the presence of irrigation networks, which increase relative humidity, a key factor for the survival of *Rhipicephalus (Boophilus)* ticks. *H. marginatum* and *H. excavatum* were the second (14.12%) and third (13.32%) most abundant species among all ticks collected across the two surveyed provinces. A recent study in India confirmed the presence of *T. annulata* in natural populations of *H. marginatum*, demonstrating its important role in transmission under natural conditions (Velusamy et al. 2023). *Hyalomma marginatum* is a prominent tick vector responsible for transmitting various pathogens, including the Crimean–Congo hemorrhagic fever virus (CCHFV) to humans by tick bite or through handling of tissues or blood from infected cattle (Celina and Černý 2025). The role of *Hyalomma lusitanicum* in the transmission of *Theileria annulata* to cattle has been investigated. A study demonstrated that this tick species is capable of transmitting the protozoan parasite responsible for Mediterranean or tropical theileriosis (Valcárcel 2023). The three *Rhipicephalus* species (*R. sanguineus*, *R. bursa*, and *R. turanicus*) were found in both regions, all with low prevalence (P<10) and low abundance (A<0.1). No reports are linking these three species to the transmission of *T. annulata* to cattle. Certain species of the genus *Rhipicephalus* are known to transmit rickettsiae, as is the case with *R. sanguineus* (Santos-Silva et al 2023). This study showed that the type of breeding significantly influenced the infection of cattle by *T. annulata* (K=0.60). Indeed, the results showed that 100% of traditional farms were contaminated and 91.66% of cattle raised on traditional farms were infected, while only 33.75% of cattle raised on modern farms were infected. Similar findings were reported in a study conducted in Egypt (El Damaty et al. 2022) and in Algeria (Kernif et al 2024).

A partial explanation for this may be that both traditional farms and most modern farms are constructed with brick, clay, and hay, which provide ideal shelters for *H. scupense*. This tick is known to be domestic and endophilic, with its immature stages using wall cracks and crevices as refuges (El Haj et al. 2002). A previous study

in Tunisia found that among the strategies to control bovine theileriosis, plastering the walls of livestock buildings (including the external and internal surfaces, as well as the ceiling) and cleaning the barn and its perimeter were the most effective methods, as they eliminated these refuges for *H. scupense* (Gharbi et al. 2006). This study also showed that crossbred cattle were more susceptible to *T. annulata* infection. Indeed, 90.35% of crossbred cattle were seropositive, while only 24% of local breed cattle were seropositive. According to our statistical analysis ($K=0.68$), the origin of the cattle has a significant influence on infection by *T. annulata*.

Conclusions

This study indicates that despite fifty years of introducing new cattle breeds to Morocco, the epidemiological situation of tropical theileriosis remains unstable in many cattle-rearing regions. Al Haouz and Fkih Ben Salah have become key foci of the disease, providing favourable conditions for ticks. The findings also highlight that this pathology is increasingly prevalent in previously disease-free areas. While treatments for theileriosis have emerged, their effectiveness varies, and the disease continues to represent a significant economic burden for farmers. The presence of potential new vectors, such as *H. dromedarii* and *H. lusitanicum*, warrants further investigation, particularly regarding their possible role in transmitting the disease amidst the current climate and agroecological changes in the surveyed regions.

Additionally, this study highlighted the significant presence of *H. marginatum*, a species known to transmit pathogens to humans, including the virus responsible for Crimean-Congo haemorrhagic fever, as demonstrated by several studies, particularly in European countries. The data provided here on *H. marginatum* may help enhance our understanding of its life cycle and seasonal dynamics in the context of climate change. This is particularly relevant as *H. marginatum* migrates via birds between Africa and Europe, passing through Morocco, a critical crossroads between these two continents.

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Data Availability: The data are available upon reasonable request from the corresponding author.

Ethics Statement: All animals involved in this study were managed by their owners and our work consisted solely of observational assessments and/or routine blood or tick sampling. These procedures were performed with the consent of the farmers and did not cause harm or distress to

the animals.

We confirm that all procedures complied with the relevant local regulations and guidelines for animal welfare at the time of the study.

Author's Contribution: Tarik RAHALI: Conceptualization; Methodology; Investigation; Resources; Writing - Original Draft Fatima Ezzahra AMARIR: Review and Visualization Abderrahim SADAK: Supervision; Validation; Writing - Review & Editing Abdelkbir RHALEM: Conceptualization; Methodology; Resources; Project Administration;

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REFERENCES

- Agina OA, Shaari MR, Isa NMM, Ajat M, Zamri-Saad M and Hamzah H, 2020. Clinical pathology, immunopathology and advanced vaccine technology in bovine theileriosis: A Review. *Pathogens* 9 (9): 697. <https://doi.org/10.3390/pathogens9090697>
- Ait Hamou S, Rahali T, Sahibi H, Belghyti D, Losson B, Goff WL and Rhalem A, 2012. Molecular and serological prevalence of *Anaplasma marginale* in cattle of North Central Morocco. *Research in Veterinary Science* 93: 1318-1323. <https://doi.org/10.1016/j.rvsc.2012.02.016>
- Aouali N, Sekkai A, Djouaher T, Messaoudi Z, Ziam H, Boutellis A and Kernif T, 2024. Molecular characterization of *Hyalomma scupense* and its vector-borne pathogen *Theileria annulata* in Ksar El Boukhari (Medea, Algeria). *Comparative Immunology, Microbiology and Infectious Diseases* 114: 102243. <https://doi.org/10.1016/j.cimid.2024.102243>
- Bedouhene A, Kelanemer R, Medrouh B, Kernif T, Saidi F, Tail G and Ziam H, 2022. Seasonal dynamics and predilection sites of ticks (Acari: Ixodidae) feeding on cows in the western parts of the Djurdjura, Algeria. *Frontiers in Tropical Diseases* 3: 856179. <https://doi.org/10.3389/fitd.2022.856179>
- Benchikh Elfegoun MC, Kohil K, Gharbi M, Afoutni L and Benachour ML, 2019. Cinétique d'infestation par les tiques des bovins de la région subhumide de Constantine en Algérie. *Revue d'Élevage et de Médecine Vétérinaire des Pays Tropicaux* 72: 41. <https://doi.org/10.19182/remvt.31726>
- Bonnet SI, Bertagnoli S, Falchi A, Figoni J, Fite J, Hoch T, Quillery E, Moutailler S, Raffetin A, René-Martellet M, Chalvet-Monfray K, Choumet V, Devillers E, Legras-Lachuer C, Vourc'h G and Faure E, 2023. An Update of Evidence for Pathogen Transmission by Ticks of the Genus *Hyalomma*. *Pathogens* 12(4): 513. <https://doi.org/10.3390/pathogens12040513>
- Bouattour A, Darghouth MA and Ben Miled L, 1996. Cattle infestation by *Hyalomma detritum* ticks and prevalence of *Theileria* in *Hyalomma detritum* species in Tunisia. *Veterinary Parasitology* 65: 256-263. [https://doi.org/10.1016/S0304-4017\(96\)00951-X](https://doi.org/10.1016/S0304-4017(96)00951-X)

- Boukhaboul A, Khemiri A and Gharbi M, 2023. Economic losses caused by tick-borne diseases in cattle: Focus on tropical theileriosis in North Africa. *Ticks and Tick-borne Diseases* 14(1): 102123. <https://doi.org/10.1016/j.ttbdis.2022.102123>
- Burridge MJ, 1971. Application of the indirect fluorescent antibody test in experimental East Coast fever (*Theileria parva* infection of cattle). *Research in Veterinary Science* 12: 339-341.
- Celina SS and Černý J, 2025. *Hyalomma marginatum* in Europe: The Past, Current Status, and Future Challenges-A Systematic Review. *Transboundary Emerging Diseases* 2025: 7771431. <https://doi.org/10.1155/tbed/7771431>
- Chaudhry ZI, Khan MN and Hussain M, 2022. Economic significance of tropical theileriosis in cattle: A review. *Livestock Science* 257: 104855. <https://doi.org/10.1016/j.livsci.2021.104855>
- Darghouth MA, Bouattour A, Ben Miled L, Kilani M and Brown CGD, 1996. Epidemiology of tropical theileriosis (*Theileria annulata* infection of cattle) in an endemic region of Tunisia: characterization of endemicity states. *Veterinary Parasitology* 65: 199-211. [https://doi.org/10.1016/S0304-4017\(96\)00974-0](https://doi.org/10.1016/S0304-4017(96)00974-0)
- Elati K, Bouaicha F, Dhibi M, Ben Smida B, Mhadhbi M, Obara I, Amairia S, Bouajila M, Rischkowsky B, Rekek M and Gharbi M, 2021. Phenology and phylogeny of *Hyalomma* spp. ticks infesting one-humped camels (*Camelus dromedarius*) in the Tunisian Saharan bioclimatic zone. *Parasite* 28: 44. <https://doi.org/10.1051/parasite/2021038>
- El Damaty HM, Yousef SG, El-Balkemy FA, Nekouei O, Mahmmod YS and Elsohaby I, 2022. Seroprevalence and risk factors of tropical theileriosis in smallholder asymptomatic large ruminants in Egypt. *Frontiers in Veterinary Science* 11: 1004378. <https://doi.org/10.3389/fvets.2022.1004378>
- Elhachimi L, Rogiers C, Casaert S, Fellahi S, Van Leeuwen T, Dermauw W, Valcárcel F, Olmeda ÁS, Daminet S, Khatat SEH, Sahibi H and Duchateau L, 2021. Ticks and tick-borne pathogens abundant in the cattle population of the Rabat-Sale Kenitra region, Morocco. *Pathogens* 10(12): 1594. <https://doi.org/10.3390/pathogens10121594>
- El Haj N, Kachani M, Ouhelli H, Boslikhane M, Ahami AT, EL Guennouni R, EL Hasnaoui M, Katende JM and Morzaria SP, 2002. Études épidémiologiques sur *Babesia bigemina* au Maroc. *Revue de Médecine Vétérinaire* 153: 809-814.
- Flach EJ and Ouhelli H, 1992. The epidemiology of tropical theileriosis (*Theileria annulata* infection in cattle) in an endemic area of Morocco. *Veterinary Parasitology* 44: 51-65. [https://doi.org/10.1016/0304-4017\(92\)90143-W](https://doi.org/10.1016/0304-4017(92)90143-W)
- Flach EJ, Ouhelli H, Waddington D and El Hasnaoui M, 1993. Prevalence of *Theileria* in the tick *Hyalomma detritum detritum* in the Doukkala region of Morocco. *Medical and Veterinary Entomology* 7: 343-350. <https://doi.org/10.1111/j.1365-2915.1993.tb00703.x>
- Ganaie Z, Shahardar R, Maqbool I, Bulbul K, Allaie I and Wani Z, 2019. An overview of bovine theileriosis. *International Journal of Veterinary Sciences and Animal Husbandry* 4(1): 09-13. <https://www.doi.org/10.22271/veterinary>
- Gharbi M, Sassi L, Dorchie P and Darghouth MA, 2006. Infection of calves with *Theileria annulata* in Tunisia: Economic analysis and evaluation of the potential benefit of vaccination. *Veterinary Parasitology* 137(3-4): 231-241. <https://doi.org/10.1016/j.vetpar.2006.01.015>
- Gharbi M, Darghouth MA, Elati K, AL-Hosary AA, Ayadi O, Salih DA, El Hussein AM, Mhadhbi M, Khbou MK, Hassan SM, Obara I, Ahmed LS and Ahmed J, 2020. Current status of tropical theileriosis in northern Africa: A review of recent epidemiological investigations and implications for control. *Transboundary and Emerging Diseases* 67: 8-25. <https://doi.org/10.1111/tbed.13312>
- García Fernández PV, Caballero G and Víseras Alarcón J, 2006. Detection of *Theileria annulata* in the parasitic ixodids of the Spanish fighting bull by the nested-PCR technique. *Revista Ibérica de Parasitología* 66: 3-16. <https://socepa.org/paraconocernos/revista-iberica-de-parasitologia/>
- Jacquet P, Dia ML, Perie NM, Jongejan F, Uilenberg G and Morel PC, 1990. Présence de *Theileria annulata* en Mauritanie. *Revue d'Élevage et de Médecine Vétérinaire des Pays Tropicaux* 43: 489-490. <https://doi.org/10.19182/remvt.8770>
- Kachani M, Spooner RL, Rae P, Bell-Sakyi L and Brown CGD, 1992. Stage-specific responses following infection with *Theileria annulata* as evaluated using ELISA. *Parasitology Research* 72: 43-47. <https://doi.org/10.1007/BF00936180>
- Kernif T, Medrouh B, Harrat Z, Saidi F and Ziam H, 2024. Characterisation of field tropical Theileriosis and associated risk factors in two bioclimatic areas of Algeria. *Ticks and Tick-Borne Diseases* 15(2): 102310. <https://doi.org/10.1016/j.ttbdis.2024.102310>
- Kumar B, Manjunathachar HV and Ghosh S, 2020. A review on *Hyalomma* species infestations on human and animals and progress on management strategies. *Heliyon* 9(12): e05675. <https://doi.org/10.1016/j.heliyon.2020.e05675>
- Liu J, Guan G and Yin H, 2022. *Theileria annulata*. *Trends in Parasitology* 38(3): 265-266. <https://doi.org/10.1016/j.pt.2021.11.001>
- Mackiewicz M, Seitzer U, Ahmed JS and Reiling N, 2020. *Theileria annulata* surface protein (TaSP) is a target of cyclin-dependent kinase 1 phosphorylation in *Theileria annulata*-infected cells. *Transboundary and Emerging Diseases* 67: 40-55. <https://doi.org/10.1111/tbed.13458>
- Margolis L, Esch GW, Holmes JC, Kuris AM and Shad GA, 1982. The use of ecological terms in parasitology (Report of an ad hoc committee of the American Society of Parasitologists). *Journal of Parasitology* 68: 131-133. <http://dx.doi.org/10.2307/3281335>
- Ouhelli H and Pandey VS, 1982. Prevalence of cattle ticks in Morocco. *Tropical Animal Health and Production* 14: 151-154. <https://doi.org/10.1007/BF02242145>
- Ouhelli H, 1988. Ecologie des *Hyalomma* (Ixodidae) parasites des bovins au Maroc. *Acta Parasitologica Polonica* 33: 273-284.
- Ouhelli H and Flach E, 1990. Epidemiology and control of theileriosis in Morocco. In: T.T. Dolan (eds), *Proceedings of a workshop held at ILRAD, Recent developments in the research and control of Theileria annulata*, 1990, Nairobi, Kenya, 19-20.
- Perveen N, Muzaffar SB and Al-deeb MA, 2021. Ticks and Tick-Borne Diseases of Livestock in the Middle East and North Africa: A Review. *Insects* 12: 83. <https://doi.org/10.3390/insects12010083>
- Rahali T, Sahibi H, Sadak A, Ait Hamou S, Losson B, Goff WL and Rhalem A, 2014. Séroprévalence et facteurs de risque des hémoparasitoses (theilériose, babésiose et anaplasmosé) chez les bovins dans quatre grandes régions d'élevage du Maroc. *Revue d'Élevage et de Médecine Vétérinaire des Pays Tropicaux* 67(4): 235-240. <https://doi.org/10.19182/remvt.20566>
- Rahali T, Rhalem A, Sadak A, Ait Hamou S, Saadi A, Losson B, Madder M and Sahibi H, 2016. Seasonal abundance of ticks (Acari/ Ixodidae) infesting cattle in four irrigated regions in Morocco. *Revue Marocaine des Sciences Agronomiques et Vétérinaires* 4(1): 37-45.
- Santos-Silva S, Santos N, Boratyński Z, Mesquita JR and Barradas PF, 2023. Diversity of Rickettsia spp. in ticks from wild mammals of Morocco and Mauritania. *Ticks and Tick-Borne Diseases* 14(6): 102235. <https://doi.org/10.1016/j.ttbdis.2023.102235>
- Singh DK, 1991. Theileriosis in India. In: D.K. Singh, B.C. Varshney (eds), *Proceedings of Second EEC Workshop on Orientation and Co-ordination of Research on Tropical*

- Theileriosis, National Dairy Development Board, Anand, India, 23-28.
- Strydom T, Lavan RP, Torres S and Heaney K, 2023. The economic impact of parasitism from nematodes, trematodes and ticks on beef cattle production. *Animals* 13(10): 1599. <https://doi.org/10.3390/ani13101599>
- Tripathi AK and Jaiswal M, 2024. Bovine tropical theileriosis: An update. In *Parasitic Infectious Diseases. Annual Volume 2024*. <https://doi.org/10.5772/intechopen.110729>
- Valcárcel F, Elhachimi L, Vilá M, Tomassone L, Sánchez M, Selles SMA, Kouidri M, González MG, Martín-Hernández R, Valcárcel Á, Fernández N, Tercero JM, Sanchis J, Bellido-Blasco J, González-Coloma A and Olmeda AS, 2023. Emerging *Hyalomma lusitanicum*: From identification to vectorial role and integrated control. *Medical and Veterinary Entomology* 37(3): 425–459. <https://doi.org/10.1111/mve.12660>
- Velusamy R, Ponnudurai G, Alagesan A, Rani N, Kolte SW and Rubinibala B, 2023. Epidemiology and molecular characterization of *Theileria annulata* in ticks collected from cattle in the central part of Tamil Nadu, India. *Parasitology Research* 122: 3077-3086. <https://doi.org/10.1007/s00436-023-07998-x>
- Walker AR, Bouattour A, Camicas JL, Estrada-Pena A, Horak IG, Latif AA, Pegram RG and Preston PM, 2003. *Ticks of Domestic Animals in Africa A Guide to Identification of Species*. Available at: http://www.researchgate.net/publication/259641898_Ticks_of_domestic_animals_in_Africa_a_guide_to_identification_of_species/file/5046352d0429878d7f.pdf
- Zweygarth E, Nijhof AM, Knorr S, Ahmed JS, Al-Hosary ATA, Obara I, Bishop RP, Josemans AI and Clausen PH, 2020. Serum-free in vitro cultivation of *Theileria annulata* and *Theileria parva* schizont-infected lymphocytes. *Transboundary and Emerging Diseases* 67: 35-39. <https://doi.org/10.1111/tbed.13348>